

# **Surface Water**

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#### Overview

Lawrence Livermore National Laboratory monitors surface water at the Livermore site, in surrounding regions of the Livermore Valley, and at Site 300 and vicinity in the nearby Altamont Hills. At the Livermore site and vicinity, LLNL monitors reservoirs and ponds, the Livermore site swimming pool, the Drainage Retention Basin (DRB), rainfall, tap water, and storm water runoff. At Site 300 and vicinity, surface water monitoring encompasses rainfall, cooling tower discharges, and storm water runoff.

The water samples are analyzed for radionuclides, high explosives, total organic carbon, total organic halides, total suspended solids, conductivity, pH, chemical oxygen demand, total dissolved solids, oil and grease, metals, minerals, anions, and a wide range of organic compounds. In addition, bioassays are performed annually on water entering and leaving the Livermore site via the Arroyo Las Positas pathway, discharges from the DRB, and water contained in the DRB.

## Storm Water

This section discusses general storm water information (including permits, constituent criteria, inspections, and sampling), sampling methods, and results.

## Introduction

## **Permits**

The goals of the storm water (runoff water) monitoring program are to demonstrate compliance with permit requirements, aid in implementing the Storm Water Pollution Prevention plans (SWPPPs) (Eccher et al. 1994a and b), and measure the effectiveness of the Best Management Practices (BMPs) in preventing contamination of storm water discharges.



LLNL monitors storm water at the Livermore site in accordance with a "Waste Discharge Requirements and National Pollutant Discharge Elimination System Permit" (NPDES Permit No. CA0030023, WDR 95-174) issued in 1995 by the San Francisco Bay Regional Water Quality Control Board. In 1994, the Central Valley Regional Water Quality Control Board (RWQCB) issued a "Waste Discharge Requirements and National Pollutant Discharge Elimination System Permit" (NPDES Permit No. CA0081396, WDR 94-131) for Site 300. These permits replaced the Statewide General NPDES Permit for Storm Water Discharges Associated with Industrial Activities (Order No. 91-13-DWQ). These permits include specific monitoring and reporting requirements. LLNL monitors additional storm water constituents not required by the permits to provide a more complete water quality profile. The current list of analyses requested for storm water samples is given in Table 7-1.

**Table 7-1.** Analyses conducted on storm water samples, 1998.

Livermore site	Site 300
Specific conductance	Specific conductance
Total suspended solids	Total suspended solids
pН	рН
Chemical oxygen demand	Potassium
Biochemical oxygen demand	Beryllium
Fish bioassay (fathead minnow)	Mercury
Anions	Volatile organic compounds
General minerals	Semivolatile organic compounds
Metals	Pesticides
Herbicides	Total organic halides
Oil and grease	Total organic carbon
Total organic carbon	Explosives
Gross alpha and beta	Gross alpha and beta
Tritium	Tritium
Plutonium	Uranium
	Plutonium

The NPDES permits for storm water require that LLNL sample effluent two times per year. In addition, LLNL is required to visually inspect the storm drainage system monthly during the wet season, whenever significant storms occur, and twice during the dry season to identify any dry weather flows. Influent sampling is also required at the Livermore site. LLNL monitors up to two more storm events each year (a total of four



sampling events) in support of DOE Orders 5400.1 and 5400.5. In addition, annual facility inspections are required to ensure that the Best Management Practices are adequate and implemented.

Storm water monitoring is also driven by the requirements in the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. Department of Energy 1991); DOE Order 5400.1, General Environmental Protection Program; DOE Order 5400.5, Radiation Protection of the Public and the Environment; and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Record of Decision (ROD).

## Constituent Criteria

Currently, there are no numerical criteria that limit concentrations of specific constituents in storm water effluent. The Environmental Protection Agency (EPA) established benchmark values for 41 parameters, but stressed that these concentrations were not intended to be interpreted as effluent limits. Rather, the values are levels that the EPA has used to determine if storm water discharged from any given facility merits further monitoring. These and other water quality criteria developed by California and the federal government were used as comparisons with LLNL storm water analytical results in this report. Although these criteria are not directly applicable to storm water effluent, use of a broad range of criteria can help evaluate LLNL's storm water management program and ensure high quality storm water effluent.

Storm water sample results for the Livermore site were also compared with criteria listed in the *Water Quality Control Plan, San Francisco Bay Basin* (San Francisco Bay RWQCB 1995), and results for Site 300 were compared with criteria listed in *The Water Quality Control Plan* (*Basin Plan*) for the *California Regional Water Quality Control Board, Central Valley Region* (Longley et al. 1994). Criteria in the basin plans include surface water quality objectives for the protection of aquatic life and water quality objectives for waters designated for use as domestic or municipal supply or agricultural supply. These criteria include, by reference, California Maximum Contaminant Levels (MCLs) for drinking water. In addition, results were compared with EPA MCLs and ambient water quality criteria (AWQC), as well as California AWQC. Criteria not specifically listed in the basin plans were obtained from *A Compilation of Water Quality Goals* (Marshack 1998). Criteria are summarized in Table 7-1 in the Data Supplement, which lists Primary Maximum Contaminant Level /Secondary Maximum Contaminant Level (PMCL/SMCL), Ambient Water Quality Criteria/Criteria for Agricultural Use (AWQC/Ag), and the EPA benchmark.



In addition to chemical-specific monitoring, LLNL is required by NPDES permit (WDR 95-174) to conduct acute and chronic fish toxicity testing in Arroyo Las Positas (Livermore Site) once per "wet season" (defined as October of one year through April of the following year). LLNL is currently not required to test for fish toxicity at Site 300.

## Inspections

Each directorate at LLNL conducts an annual inspection of its facilities to verify implementation of the Storm Water Pollution Prevention Plans (SWPPPs) and to ensure that measures to reduce pollutant loadings to storm water runoff are implemented. The Associate Directors certify that their facilities comply with the provisions of WDR 94-131, WDR 95-174, and the SWPPPs. The Deputy Director for Operations certifies for facilities directly reporting to the Director's Office, except those facilities in the Laboratory Site Operations organization, which are certified by the Laboratory Site Manager. LLNL submits annual storm water monitoring reports to the San Francisco Bay RWQCB and to the Central Valley RWQCB, reporting the results of sampling, observations, and inspections.

LLNL also meets the storm water compliance monitoring requirements of the General Construction Activity Storm Water Permit for construction projects disturbing two hectares of land or more. Monitoring for these construction projects included visual observations of sites before and after storms to assess the effectiveness of implemented best management practices. Annual compliance certifications summarize these inspections.

As they have for the past two years, the San Francisco Bay RWQCB requested submission of compliance status reports for the Livermore site projects. Since the inception of the General Construction Activity Storm Water Permit, the Central Valley RWQCB has not requested these status reports for projects located at Site 300. The 1997 compliance certifications covered the period of June 1997 through May 1998. During this period, three Livermore site projects were inspected: the Decontamination and Waste Treatment Facility (DWTF), the National Ignition Facility (NIF), and the areas associated with the Soil Reuse Project. One Site 300 project, the Contained Firing Facility (CFF), was also inspected under this program.

## Sampling

To evaluate the overall impact of Livermore site and Site 300 operations on storm water quality, storm water flows are sampled where they enter and exit the sites. Flow patterns at the Livermore site are such that storm water at sampling locations includes water from other sources, such as neighboring agricultural land, parking lots, and landscaped areas. In contrast, storm water at Site 300 is sampled at locations that target



specific industrial activities, with negligible run-on from other sources. These samples provide information used to evaluate the effectiveness of LLNL's storm water pollution control program.

#### Livermore Site

The natural drainage at the LLNL Livermore site was altered by construction activities several times up to 1966 (Thorpe et al. 1990) so that the current northwest flow of Arroyo Seco and the westward flow of Arroyo Las Positas do not represent historical flow paths. About 1.6 km to the west of the Livermore site, Arroyo Seco merges with Arroyo Las Positas, which continues to the west to eventually merge with Arroyo Mocho (see **Figure 7-1**).

The Drainage Retention Basin (DRB) was excavated and constructed for storm water diversion and flood control. It collects about one-fourth of the surface water runoff from the site and a portion of the Arroyo Las Positas drainage (**Figure 7-2**). This basin was lined to prevent infiltration.

The DRB discharges north to a culvert that leads to Arroyo Las Positas. The remainder of the site drains either directly or indirectly into the two arroyos by way of storm sewers and ditches. Arroyo Seco cuts across the southwestern corner of the site. Arroyo Las Positas, diverted from its natural course, follows the northeastern and northern boundaries of the site and exits the site near the northwest corner.

The Livermore site storm water runoff sampling network consists of 13 locations (**Figure 7-2**). Six locations characterize storm water either entering (influent: ALPE, ALPO, GRNE, and ASS2) or exiting (effluent: WPDC and ASW) the Livermore site. Locations CDB and CDB2 characterize runoff from the southeastern quadrant of the Livermore site entering the DRB, and location CDBX characterizes water leaving the DRB. Four on-site locations (196E, 196S, WPDS, and WPDW) were used in a tritium source investigation.

#### Site 300

Surface water at Site 300 consists of seasonal stream runoff, springs, and natural and man-made ponds. The primary waterway in the Site 300 area is Corral Hollow Creek, an ephemeral stream that borders the site to the south and southeast. No continuously flowing streams are present in the Site 300 area. Elk Ravine is the major drainage channel for most of Site 300; it extends from the northwest portion of the site to the east-central area (see **Figure 9-3**). Elk Ravine drains the center of the site into Corral Hollow Creek,



which drains eastward to the San Joaquin River Basin. Some smaller canyons in the northeast portion of the site drain to the north and east toward Tracy.

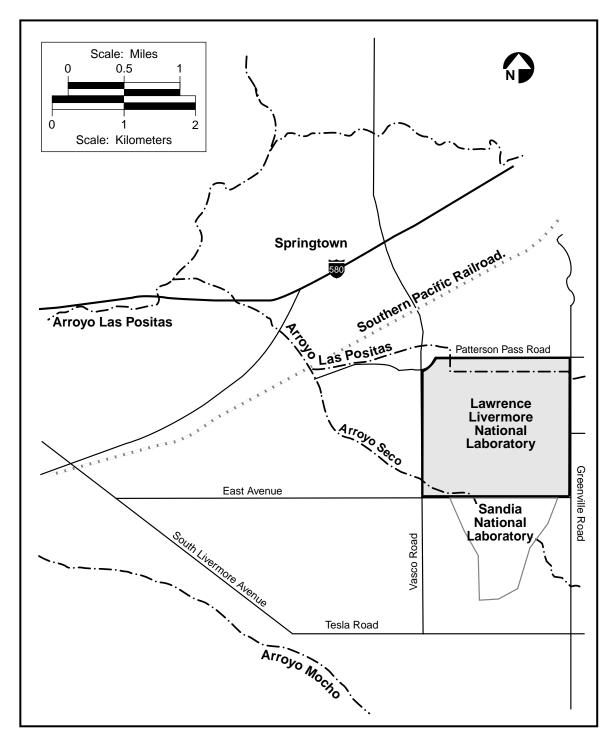
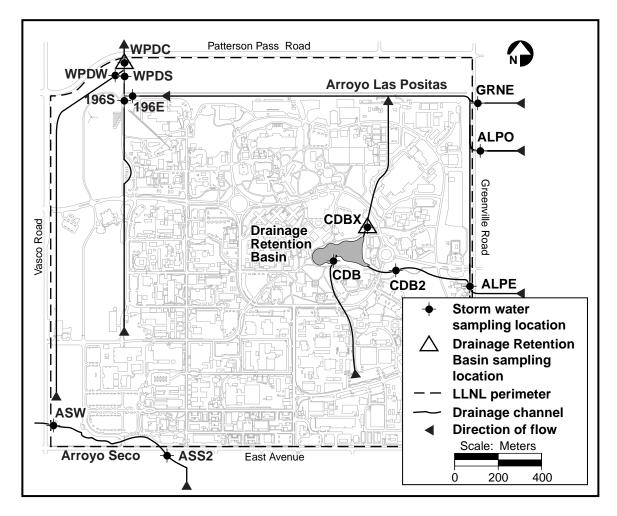


Figure 7-1. Surface water flow in the vicinity of LLNL.





**Figure 7-2.** Storm water runoff and Drainage Retention Basin discharge sampling locations, Livermore site and vicinity, 1998.

There are at least 23 springs at Site 300. Nineteen are perennial, and four are intermittent. Most of the springs have very low flow rates and are recognized only by small marshy areas, pools of water, or vegetation. A number of surface water bodies are present at Site 300 and vicinity. A sewage evaporation pond and a sewage percolation pond are located in the southeast corner of the site in the General Services Area (GSA), and two lined high explosives (HE) process water impoundments are located to the west in the Explosives Process Area. Monitoring results associated with these facilities are reported in Chapter 9.

Other surface water flow at Site 300 results from blowdown water from cooling towers in the Building 801 complex in the East/West Firing Area and Building 836 in the 832



canyon. Cooling tower discharges and their potential impact are discussed in the *Final Site-Wide Remedial Investigation* Report (Webster-Scholten 1994).

The Site 300 storm water sampling network began in 1994 with six locations and now consists of seven locations (**Figure 7-3**). Location CARW is used to characterize runoff in Corral Hollow Creek upgradient and, therefore is unaffected by Site 300 activities.

Location GEOCRK is used to characterize runoff in Corral Hollow Creek, downgradient of Site 300. The remaining locations were selected to characterize storm water runoff at locations that could be affected by specific Site 300 activities.

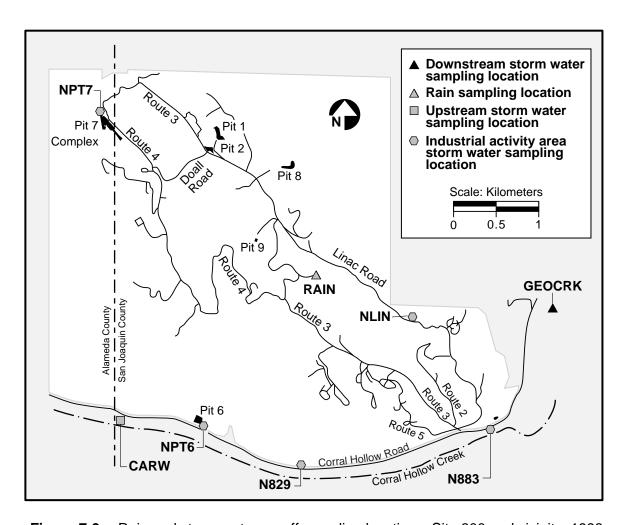


Figure 7-3. Rain and storm water runoff sampling locations, Site 300 and vicinity, 1998.



## Methods

Samples are collected by grab sampling from the runoff flow at specified locations. Sample bottle requirements, special sampling techniques, and preservation requirements for each analyte are specified in the *Environmental Monitoring Plan* (Tate et al. 1995), and summarized below.

If the water to be sampled is accessible to the technician, grab samples are collected by partially submerging sample bottles directly into the water and allowing them to fill with the sample water. If the water to be sampled is not directly accessible, a stainless steel bucket is used for sampling. The bucket is triple-rinsed with the water to be sampled, then dipped or submerged into the water, and withdrawn in a smooth motion. Sampling is conducted away from the edge of the water to minimize the collection of sediment with the sample matrix. Sample vials for volatile organics are filled first, before sample vials for all other constituents and parameters.

## Results

## Inspections

Inspections at the Livermore site noted a few instances of products or equipment stored uncovered outside, a product storage compartment in need of repairs, two pieces of equipment leaking oil, and one drain to ground that was not appropriately labeled. Inspections at Site 300 noted one leaking faucet. Clean-up and repairs are under way in all cases. A number of findings were associated with the LLNL cafeterias. Trash-bin lids were damaged or missing, small amounts of tallow oil (from 1 tablespoon to 3 cups) had been spilled to soil, and grease had leaked from two fume hoods. Clean-up is in progress, and training is being given to the subcontractors to prevent any recurrences.

The following exceptions to the General Construction Activity Storm Water Permit requirements were documented:

- Inspections of the CFF construction site at Site 300 were not documented during the shut down of construction activities from December 1997 through May 1998.
- Inspections based on the prediction of a rain event were not performed for the Soil Reuse Project at the Livermore site.



An erosion control Best Management Practice (BMP) for the Soil Reuse Project at the Livermore site was not implemented as specified in the SWPPP. However, no erosion resulted from this BMP lapse.

Finally, there were four exceptions associated with the National Ignition Facility (NIF) project at the Livermore site. Two of these were for failure to implement the correct BMP. In addition, water from a broken line was drained into a trench without filtering entrained sediments, and on one occasion a road was cleaned by flushing it with water rather than sweeping. Inspections were not performed or documented for one subproject that was fast-tracked.

## Livermore Sampling

LLNL collected storm water samples at all Livermore site locations on February 12, March 31, and November 30, 1998. Fish toxicity testing for the 1998/1999 season was delayed into 1999 because the laboratory could not meet the holding time requirement for the November 30, 1998, sample.

## Livermore Site Radioactive Constituents.

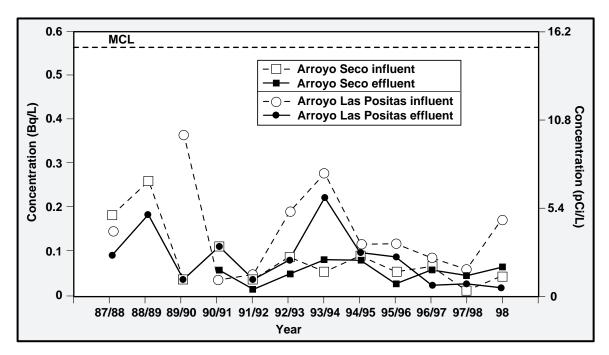
Storm water tritium, gross alpha, and gross beta results are summarized in Table 7-2. Complete results are in the Data Supplement, Table 7-2. Median activities were 10% or less than the respective MCLs. **Figures 7-4** and **7-5**, which show the historical trend in storm water gross alpha and gross beta, respectively, do not reveal a discernible trend. In these and other storm water historical trend figures in this chapter, all available data for the influent and effluent locations of the two runoff pathways through the Livermore site have been aggregated. Also, data have been aggregated on a wet season basis—that is, October of one year through May of the next—rather than on a calendar year basis. The 1998 points represent a partial wet season, pending collection of 1999 data, and are based on only one sampling event (November 30, 1998).

**Table 7-2.** Radioactivity (in Bq/L) in storm water runoff, Livermore site, 1998.

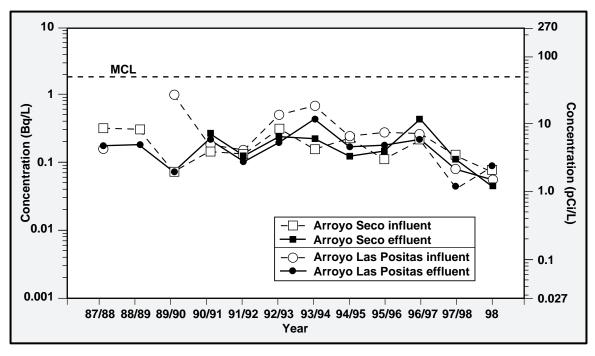
	Tritium	Gross alpha	Gross Beta
Median	2.40	0.05	0.11
Minimum	0.21	0.01	0.004
Maximum	31.4	0.38	0.32
Interquartile range	5.37	0.08	0.08
MCL <sup>(a)</sup>	740	0.555	1.85

MCL = Maximum Contamination Level





**Figure 7-4.** Annual median gross alpha concentrations in LLNL storm water compared with the maximum contaminant level (MCL).



**Figure 7-5.** Annual median gross beta concentrations in LLNL storm water compared with the maximum contaminant level (MCL).

The historical trend in tritium levels (Figure 7-6), which correlates with decreased emissions (see Chapter 5), indicates generally decreasing tritium levels in storm water from a peak in the 1988/1989 season. However, for the 1996/1997 and 1997/1998 seasons, the tritium concentration in Arroyo Las Positas was higher when storm water left the site than when it entered the site. In addition, on May 23, 1997, at location WPDC, where effluent is measured, a single, higher-than-typical result for tritium in storm water (359 Bq/L) was measured. Also, although the November 30, 1998, WPDC tritium result was 1.1 Bq/L just upstream at location WPDS, the tritium concentration was 31 Bq/L. The reason for this apparent discrepancy was that the samples were taken several hours apart and the peak discharge was probably missed at WPDC. Thus, at some point, the tritium concentration of the effluent could have reached 30 Bq/L.

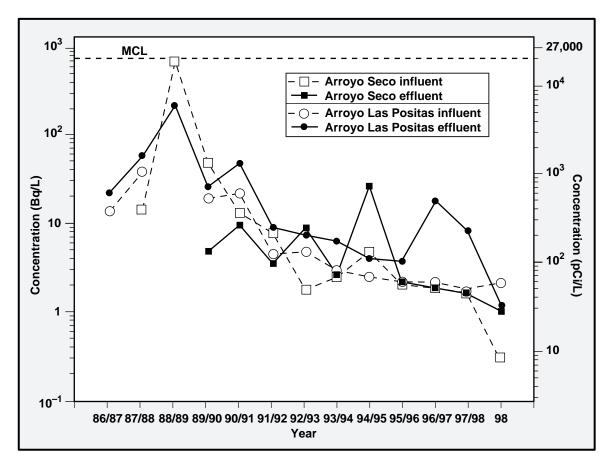


Figure 7-6. Annual median tritium concentrations in LLNL storm water compared with the maximum contamination level (MCL).



In response to the high effluent tritium concentrations, additional tritium investigations were initiated in the fall of 1998, to reconfirm the current evidence that effluent tritium concentration is greater than influent tritium concentration, and to identify sources for the higher tritium concentrations. These investigations included:

- Review of air tritium sampling results (the air tritium data during and prior to 1998 did not indicate a source for the tritium).
- Increased frequency of rain sampling.
- Increased frequency and number of locations of storm water sampling.

The initial approach taken to evaluate tritium flow patterns across the Livermore site was to evaluate two locations (WPDW and 196S) where the storm drainage channels join the main Arroyo Las Positas channel slightly upstream of where Arroyo Las Positas leaves the Livermore site effluent location (WPDC). Beginning on November 30, 1998 two samples were taken for each juncture: one sample in the incoming channel and one in Arroyo Las Positas just upstream of the juncture, for a total of four locations (WPDS, WPDW, 196E, and 196S). **Figure 7-7** depicts tritium concentrations at each location on this date. Tritium was not detected in the incoming channels (locations WPDW and 196S), but was high in the main Arroyo Las Positas channel (31 Bq/L at both WPDS and 196E). The data do not indicate a source in either of the two storm drainage channels closest to the Arroyo Las Positas effluent location. Additional locations will be added in 1999 to confirm this, and to further evaluate tritium flow patterns.

Evaluation of rain tritium revealed that, after November 7, 1997, tritium concentrations at rain location B343, designed to monitor results from the Building 331 Tritium Facility, (see **Figure 7-8**) were higher than at all other rain locations for every sample through the end of 1998 (8 sample dates in all). Tritium concentrations at the B343 location were at least 20 Bq/L higher than the next highest rain location during this time period and up to a maximum of 152 Bq/L higher than the next highest location on November 30, 1998. **Figure 7-9** plots "runoff increase" against B343 rainfall tritium concentration for available data from 1996–1998 (in this plot, the WPDS result was used for November 30, 1998 runoff effluent). Runoff increase was calculated as the difference between effluent (location WPDC) tritium concentration and the highest influent (location ALPE, ALPO, or GRNE) tritium concentration. The data suggest a relationship between tritium in rainfall at the Tritium Facility and tritium levels in storm water at WPDC. Additional data points are needed to test this hypothesis.



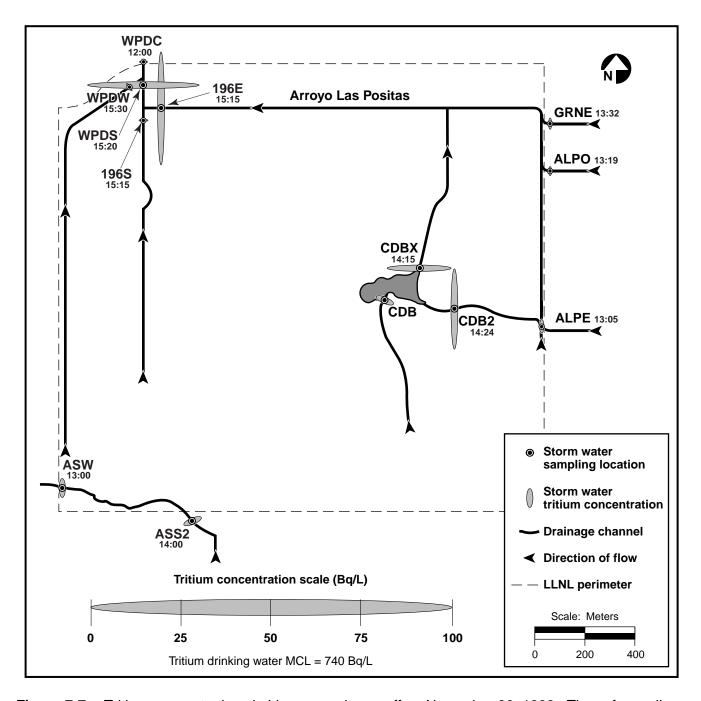


Figure 7-7. Tritium concentrations in Livermore site runoff on November 30, 1998. Time of sampling is indicated at sampling locations.



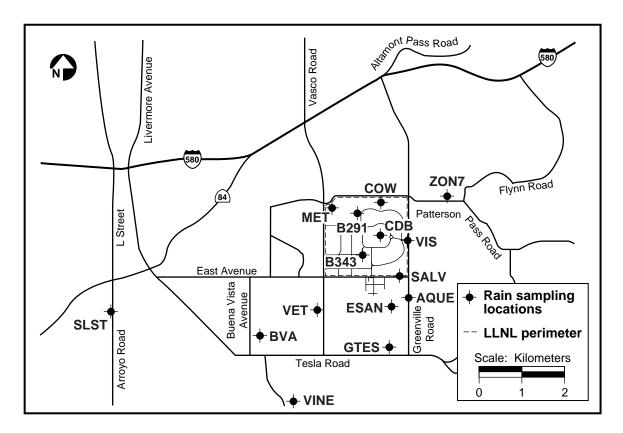


Figure 7-8. Rain sampling locations, Livermore site and Livermore Valley, 1998.

LLNL began analyzing for plutonium in runoff in 1998. Sampling was conducted at the Arroyo Seco effluent location (ASW) on February 12, and at both the Arroyo Seco and Arroyo Las Positas effluent locations (ASW and WPDC) on March 31, May 4, and November 30. In addition to analyzing plutonium in runoff water, on each date all or a portion of the sample was filtered, and the sediment analyzed to determine the plutonium levels in the sediments carried with the runoff. The only plutonium detected in runoff was  $3.17 \times 10^{-4}$  Bg/L of plutonium-238 on May 4 at location ASW, in the unfiltered sample. However, plutonium was not detected in filtered runoff or filtrate, indicating that this plutonium was caused by low levels (below background) of plutonium in the sediments. Sediment plutonium<sup>239+240</sup> in this sample was measured at  $1.44 \times 10^{-4}$  Bq/g (3.9  $10^{-3}$  pCi/g). This value is comparable to plutonium<sup>239+240</sup> levels routinely seen in sediments at the location, and well below the background level  $(4.44 \times 10^{-4} \,\mathrm{Bg/g} \,(1.2 \times 10^{-2} \,\mathrm{pCi/g}))$  for sediments. This background concentration reflects worldwide fallout and naturally occurring concentrations (See Chapter 9). The plutonium-238 result in sediment at location WPDC on November 30 was  $0.0144 \pm 0.0141$  Bq/g, an error of over 97%. Other plutonium samples, counted for

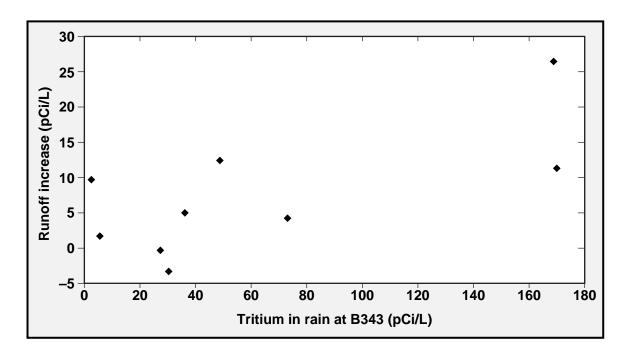


Figure 7-9. Tritium concentration in stormwater runoff at the Livermore site plotted against the tritium concentration of rain sampled at Building 343 (November, 1997 through December, 1998).

longer times, had lower detection limits, and were judged to be nondetects, indicating that the November 30 result was probably an artifact of a high detection limit. This was confirmed by submitting an archived portion of this sample reanalysis with lower detection limits. The result was no detectable plutonium (detection limit =  $3.7 \times 10^{-3}$  Bq/g (0.1pCi/g), and calculated activity of  $4.5 \times 10^{-4}$  Bq/g (0.05pCi/g)). Future samples will be counted longer to eliminate false positives at high detection limits. Thus, plutonium activities in runoff can be attributed to background levels and worldwide fallout. Complete plutonium results are found in Data Supplement Table 7-3.

#### Livermore Site Nonradioactive Constituents

**Table 7-3** and **7-4** list metals, organics, and nonradioactive constituents found above comparison criteria in Livermore site storm water. (Complete storm water results are presented in Tables 7-4, 7-5, and 7-20 of the Data Supplement.) Of greatest concern are constituents that exceeded comparison criteria at effluent points, and whose concentrations are lower in influent than in effluent. If influent concentrations are higher than effluent concentrations, the source is generally assumed to be unrelated to LLNL operations, and therefore, further investigation is not warranted.



**Table 7-3.** Metal constituents above comparison criteria (see Table 7-1 of the Data Supplement) in storm water runoff, Livermore site, 1998.

				Arroyo Seco					
Metal	Requested	EPA	Storm	Influ	uent	Efflu	uent		
(mg/L)	analysis	analysis	date	AS	SS2	AS	SW		
		method		Dissolved	Total	Dissolved	Total		
Aluminum	GENMIN	200.7	2/12		43		6.8		
	GENMIN	200.7	3/31		0.69		0.55		
	NPDESMETAL	200.7			0.98		0.75		
	GENMIN	200.7	11/30	0.28	2.5		3.7		
	NPDESMETAL	200.7		0.27	2.9	0.21	4.0		
Antimony	NPDESMETAL	204.2	3/31		0.006				
Copper	GENMIN	200.7	2/12		0.057				
	NPDESMETAL	220.2			0.088		0.026		
Iron	GENMIN	200.7	2/12		61		8.1		
	GENMIN	200.7	3/31		0.97		0.71		
	NPDESMETAL	200.7			1.3		0.95		
	GENMIN	200.7	11/30		3		4.4		
	NPDESMETAL	200.7			3.5		5.1		
Lead	NPDESMETAL	239.2	2/12		0.027				
	NPDESMETAL	239.2	3/31		0.061				
Manganese	GENMIN	200.7	2/12		1.2		0.22		
	GENMIN	200.7	3/31						
	NPDESMETAL	200.7			0.05				
	GENMIN	200.7	11/30		0.068		0.088		
	NPDESMETAL	200.7			0.074		0.097		
Nickel	GENMIN	200.7	2/12		0.12				
	NPDESMETAL	249.2			0.12				
Zinc	GENMIN	200.7	2/12		0.19		0.069		
	NPDESMETAL	200.7					0.032		
	GENMIN	200.7	3/31		0.042		0.061		
	NPDESMETAL	200.7			0.04		0.07		
	GENMIN	200.7	11/30	0.066	0.096	0.058	0.1		
	NPDESMETAL	200.7		0.055	0.1	0.054	0.12		



**Table 7-3.** Metal constituents above comparison criteria (see Table 7-1 of the Data Supplement) in storm water runoff, Livermore site, 1998 (continued).

						A	Arroyo L	os Posita	s		
Metal	Requested	EPA	Storm			Influ	uent			Effl	uent
(mg/L)	analysis	analysis	date	AL	PE	AL	.PO	GR	NE	WPDC	
		method		Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Dissolved
Aluminum	GENMIN	200.7	2/12		2.1		13		27		7
	GENMIN	200.7	3/31		5.6		2.0		2.4		1.8
	NPDESMETAL	200.7			7.3		2.9		2.8		2.7
	GENMIN	200.7	11/30		5.6		1.7		7.5		2.8
	NPDESMETAL	200.7			5.7		2.5		9.7		2.9
Antimony	NPDESMETAL	204.2	3/31								
Copper	GENMIN	200.7	2/12								
	NPDESMETAL	220.2					0.038				
Iron	GENMIN	200.7	2/12		1.9		13		29		7.8
	GENMIN	200.7	3/31		6.5		2.1		2.6		2.2
	NPDESMETAL	200.7			7.3		2.6		2.9		3.3
	GENMIN	200.7	11/30		5.1		1.6		8.0		3
	NPDESMETAL	200.7					2.2		9.7		3.4
Lead	NPDESMETAL	239.2	2/12								0.035
	NPDESMETAL	239.2	3/31								
Manganese	GENMIN	200.7	2/12		0.23		0.33		0.53		0.17
	GENMIN	200.7	3/31		0.18		0.1		0.05		0.055
	NPDESMETAL	200.7			0.2		0.12		0.05		0.07
	GENMIN	200.7	11/30		0.1				0.15		0.061
	NPDESMETAL	200.7			0.1				0.16		0.066
Nickel	GENMIN	200.7	2/12								
	NPDESMETAL	249.2									
Zinc	GENMIN	200.7	2/12		0.034		0.061		0.14		0.15
	NPDESMETAL	200.7									
	GENMIN	200.7	3/31		0.062				0.12	0.041	0.11
	NPDESMETAL	200.7			0.06			0.04	0.13	0.05	
	GENMIN	200.7	11/30		0.04				0.085		0.092
	NPDESMETAL	200.7							0.098		0.093



**Table 7-3.** Metal constituents above comparison criteria (see Table 7-1 of the Data Supplement) in storm water runoff, Livermore site, 1998 (concluded).

					Drai	inage Ret	ention E	Basin	
Metal	Requested	EPA	Storm		Infl	uent		Efflu	ient
(mg/L)	analysis	analysis	date	CI	ЭВ	CD	B2	CD	вх
		method		Dissolved	Total	Dissolved	Total	Dissolved	Total
Aluminum	GENMIN	200.7	2/12		4.3		8.1		5.9
	GENMIN	200.7	3/31		2.1		0.87		
	NPDESMETAL	200.7			1.9		1.1		
	GENMIN	200.7	11/30	0.28	2.8	0.29	6.2		2.1
	NPDESMETAL	200.7		0.26	3	0.3	6.1		2.4
Antimony	NPDESMETAL	204.2	3/31						
Copper	GENMIN	200.7	2/12						
	NPDESMETAL	220.2							
Iron	GENMIN	200.7	2/12		4.3		8.5		5.4
	GENMIN	200.7	3/31		2.4		1		
	NPDESMETAL	200.7			2.3		1		
	GENMIN	200.7	11/30		2.9		6.3		2.1
	NPDESMETAL	200.7			3.2		6.3		2.4
Lead	NPDESMETAL	239.2	2/12						
	NPDESMETAL	239.2	3/31						
Manganese	GENMIN	200.7	2/12		0.087		0.18		0.087
	GENMIN	200.7	3/31		0.052		0.081		
	NPDESMETAL	200.7			0.05		0.08		
	GENMIN	200.7	11/30		0.064		0.11		0.052
	NPDESMETAL	200.7			0.069		0.11		0.057
Nickel	GENMIN	200.7	2/12						
	NPDESMETAL	249.2							
Zinc	GENMIN	200.7	2/12		0.11		0.068		0.039
	NPDESMETAL	200.7		0.039	0.035				
	GENMIN	200.7	3/31		0.12				
	NPDESMETAL	200.7			0.12				
	GENMIN	200.7	11/30	0.088	0.13	0.049	0.11		0.034
	NPDESMETAL	200.7		0.087	0.17	0.046	0.11		0.038





**Table 7-4.** Nonradioactive constituents above comparison criteria (see Table 7-1 in the Data Supplement) in storm water runoff, Livermore site, 1998.

		Arroy	o Seco		Arroyo La	as Positas	 S	Drainag	je Retenti	on Basin
Parameter	Storm	Influent	Influent Effluent		Influent		Effluent	Infl	uent	Effluent
	date	ASS2	ASW	ALPE	ALPO GRNE		WPDC	CDB	CDB2	CDBX
Physical (mg/L)										
Chemical oxygen demand	3/31			124						
Total suspended solids (TSS)	2/12	454		370	280	748	158	154	160	
	3/31			179						
	11/30					131				
Anions (mg/L)										
Chloride	2/12				250					
	3/31			388	333				302	
	11/30									93
Fluoride	2/12				0.95					
	3/31			1.2	1.4				1.2	
	11/30				1					
Nitrate (as N)	2/12	2.8	2.8			0.71				
	3/31	1.6	1.5		2.9	4.9		1.8		
	11/30				2.2	3.3	0.89			1.7
Nitrate (as NO <sub>3</sub> )	2/12	12	12		15	3.1				
	3/31	7.2	6.7		13	22		8		
	11/30				9.5	14	4			7.5
Sulfate	2/12				304					
	3/31			317	355					
General minerals (mg/L)										
Chloride	3/31			365	331				303	
Fluoride	2/12				0.97					
	3/31			1.2	1.4				1	
	11/30				1					
	11/30				1					
Nitrate (as N)	2/12	2.8	2.8		3.3	0.72				
,	3/31	1.7	1.5		2.9	4.9	0.74	1.8		
	11/30		_		2.2	3.4	0.98	-		1.8
	11/30				2.2	3.2	0.95			1.8
Nitrate (as NO <sub>3</sub> )	2/12	12	12		15	3.2				
, <i>J</i> /	3/31	7.4	6.7		13	22	3.3	7.9		
	11/30				9.8	15	4.3			7.8
	11/30				9.5	14	4.2			7.8



**Table 7-4.** Nonradioactive constituents above comparison criteria (see Table 7-1 in the Data Supplement) in storm water runoff, Livermore site, 1998 (concluded).

		Arroy	o Seco		Arroyo La	as Positas	Drainage Retention Basin			
Parameter	Storm	Influent	Effluent		Influent		Effluent	Infl	uent	Effluent
	date	ASS2	ASW	ALPE	ALPO	GRNE	WPDC	CDB	CDB2	CDBX
General Minerals (mg/L) (continued)										
рН	2/12									5.57
	3/31								8.57	
Specific conductance (µmho)	2/12	795	735		1830					
	3/31	930	855	2300	2230				1940	
	11/30				1520					765
	11/30			866	1530					761
Sulfate	2/12				302					
	3/31			297	352					
Total alkalinity (as CaCO <sub>3</sub> )	2/12							7.1		
	11/30	15	19	20						
	11/30	19	16							
Total dissolved solids (TDS)	2/12	508			1200					
	3/31	563	517	1450	1460				1220	
	11/30				890					
	11/30			517	937					
Total phosphorus (as P)	2/12	2.1	0.45	0.68	0.86	0.35	0.24	0.13	0.37	0.68
	3/31	0.15	0.13	0.49	0.21	0.13	0.2	0.15	0.27	
	11/30	0.26	0.29	0.44	0.16	0.26	0.24	0.12	0.26	0.23
	11/30	0.24	0.23	0.42	0.14	0.27	0.21	0.12	0.24	0.21
Miscellaneous organics (mg/L)										
Total organic carbon (TOC)	2/12	9.5	12	14	14	6.1	3.4	2.9	9.6	12
	3/31	7.1	6.8	20	8.7	5.1	8.7	5.5	24	
	11/30	7.8	8	15	6.8	3.5	5.5	9	10	5.8

In 13 effluent samples, the total metal concentrations for aluminum, iron, lead, manganese, and zinc were above both criteria and influent concentrations. There was only one case (for zinc) in which the dissolved metal concentration was above both criteria and influent concentrations. Other constituents, which were above criteria and also at higher concentrations at effluent than at influent locations, were total phosphorous (two samples), and total organic carbon (four samples). In addition, for one sample, total alkalinity was less than the AWQC minimum at effluent location ASW, and less than the corresponding influent location (ASS2). A number of other



constituents in LLNL runoff were also above comparison criteria. In every case, however, when the concentration exceeded a criterion at an effluent point, there was a corresponding influent point with a higher concentration, indicating an off-site or possibly naturally occurring source.

LLNL has more than 10 years of storm water metals data. Recent data seem to indicate that concentrations of some metals are increasing in LLNL storm water effluent. However, this trend may have been influenced by changes in testing laboratories, or changes in analytical procedures used at the laboratories (specifically, a shift from procedures that recover dissolved metals to procedures that recover total metal concentrations). It was also not clear how much of the trend results from sediment loads, natural concentrations, LLNL discharges, or off-site contributions.

Beginning in the 1997/1998 wet season, source investigations were conducted to determine the relative quantities of metals being transported in solution and as suspended solids. The study also evaluated how much of the loading in each fraction (dissolved and suspended) originated off site, how much was contributed by on-site sources, and how concentrations of constituents in storm water related to concentrations of total suspended solids for a particular storm and location.

To accomplish these goals, samples for applicable constituents were collected in duplicate. One sample was analyzed for total concentration (i.e., dissolved and suspended) of the constituents of interest. The second sample was filtered in order to evaluate the dissolved component. LLNL's contracts with the analytical laboratories are designed around collections or "suites" of analyses. Metals are included in two suites identified by GENMIN (general minerals) and NPDESMETALS (metals required under NPDES). Because there is some overlap in the metals specified in these two suites, some metals were analyzed twice. In such cases, all analyses were utilized. Samples were also analyzed for concentration of total suspended solids (TSS). Metals detected above comparison criteria are presented in **Table 7-3** (full results are in Table 7-4 of the Data Supplement).

In 1997, a review of metals data collected over the previous five years revealed that chromium, copper, iron, and zinc had been detected above comparison criteria in more than one year, and effluent values were higher than influent values more often in recent years. These metals were therefore selected for detailed analysis, and the results reported in the 1998 Livermore Site Annual Storm Water Monitoring Report for WDR 95-174 (Brandstetter 1998). The results of that analysis are summarized as follows:

A clear relationship was found between TSS and total metals concentrations, although there was notable variability. This variability



could be reduced by homogenizing a large storm water sample volume and then separating it into the bottles submitted for the various analyses. In 1999 samples will be collected in this manner.

- There was no relationship between dissolved concentrations and TSS.
   Only in the case of zinc was a relationship observed between dissolved concentrations and total concentrations.
- Where effluent metal concentrations were higher than influent concentrations, the data indicated that this was caused by higher TSS.
- The data indicated that the apparent trend in increasing metals
  concentrations was caused by a change from analyses that measure the
  dissolved portion (i.e., filtered), to analyses that measure total metals.
   This was compounded by the observed increase in total suspended solids
  in Arroyo Seco storm water, and the presence of metals that naturally
  occur in sediments.

Thus, while it is not completely clear how much of the historical record should be attributed to total metals analyses, it is clear that high metal concentrations are caused by the suspended solids transported in the storm water.

## Site 300

LLNL procedures specify sampling of a minimum of two storms per rainy season from Site 300. Typically, a single storm will not produce runoff at all Site 300 locations because Site 300 receives relatively little rainfall and is largely undeveloped. Therefore, at many locations, a series of large storms is required to saturate the ground before runoff occurs. In 1998, samples were collected at locations with flow on January 12, February 2, May 5, and November 30. Results are presented in Tables 7-6 and 7-7 of the Data Supplement. There was no detectable tritium in Site 300 storm water during 1998. Maximum gross alpha and gross beta were 0.14 and 0.28 Bq/L, respectively, approximately 25% and 15% of their MCLs (0.56 and 1.85 Bq/L). **Table 7-5** lists constituents found above comparison criteria in Site 300 storm water runoff. Total suspended solids were above the EPA benchmark (100 mg/L) (see Table 7-1 in the Data Supplement) five times at effluent locations, with a maximum of 6480 mg/L. All other on-site TSS concentrations were less than 1,000 mg/L.



**Table 7-5.** Constituents above comparison criteria in storm water runoff, Site 300, 1998.

Parameter	Date	Upstream location		Downstream location			
		CARW	N883	NLIN	NPT6	NPT7	GEOCRK
Specific conductance (μmho/cm)	2/2						1140
	5/5	1098					1120
Total suspended solids (TSS) (mg/L)	1/12				6480	149	
	2/2	676		940	485		
	5/5	1760			586		796
pH (pH units)	2/2		6.0				
	11/30					9.4	
Total organic carbon (TOC) (mg/L)	1/12		3.0		4.1	2.1	
	2/2	7.8	6.3	5.5	3.3		8.3
	5/5	6.1	16		11	5.7	4.1
	11/30		17			2.9	

Historically, upstream total suspended solid levels are frequently above 1000 to 2000 mg/L, indicating that most of these values are due to erosion typical of the region. Specific conductance was above the secondary MCL (900 µmho/cm) and agricultural criterion (700 μmho/cm) once at upstream location CARW (1098 μmho/cm) and twice at downstream location GEOCRK (1120 and 1140 µmho/cm), but was never above criteria at effluent locations. At location N883 there was one sample with a pH of 5.98, below the secondary MCL minimum of 6.5, and at location NPT7, there was one sample with a pH of 9.38, above the secondary MCL maximum of 8.5. All other parameters were below comparison criteria. Results of Pit 6 post-closure runoff monitoring are shown in Data Supplement Table 7-8.

#### Rainfall

## Introduction

Rainfall is sampled for tritium according to written procedures described in Appendix A of the Environmental Monitoring Plan (Tate et al. 1995). Historically, the tritium activity measured in rainfall in the Livermore Valley has resulted primarily from atmospheric emissions of tritiated water vapor (HTO) from stacks at LLNL's Tritium Facility (Building 331), and Sandia National Laboratories/California's former Tritium Research



Laboratory. The Building 343 rain sampling location is near the Tritium Facility (Building 331), where LLNL personnel have reduced operations in recent years and performed significant inventory reduction and cleanup activities. The total measured atmospheric emission of HTO from LLNL facilities in 1998 was 3.2 TBq (85 Ci) (see Chapter 4, Air Effluent Monitoring). The rain sampling locations for the Livermore site and Livermore Valley are shown on **Figure 7-9.** The fixed sampling locations are positioned to record a wide spectrum of tritium activities in rainfall, from the maximum expected down to background levels.

## Results

LLNL collected rainfall samples twice at the Livermore site and Livermore Valley in 1998. Complete data are shown in Table 7-9 of the Data Supplement. The Livermore site rainfall has exhibited elevated tritium activities in the past (Gallegos et al. 1994). During 1998, however, measurements of tritium activity in rainfall were all far below the 740 Bq/L (20,000 pCi/L) MCL established by the EPA for drinking water. The highest overall activity was 169 Bq/L (see **Table 7-6**) measured on December 1, 1998, near Building 343, just to the north of the Tritium Facility. This value is approximately 23% of the MCL for tritium. The highest off-site activity was 4.63 Bq/L, recorded in a sample collected from location ESAN on February 12, 1998.

**Table 7-6.** Tritium activities (in Bq/L) in rainfall for the LLNL Livermore site and the Livermore Valley.

	Livermore site	Livermore Valley
Median	5.59	1.50
Maximum	169	4.63
Minimum	1.19	0.20
Interquartile range	9.03	1.66
Number of samples	14	15 <sup>(a)</sup>

a One sample from AQUE was not collected.

The median tritium activity measured in rainfall on site at LLNL has slightly increased from 3.85 Bq/L (104 pCi/L) in 1997 to 5.59 Bq/L (151 pCi/L) in 1998. However, median tritium activity measured in rainfall on site at LLNL has decreased more than tenfold since 1990, down from 65.9 Bq/L (1780 pCi/L) to 5.59 Bq/L (151 pCi/L) (see **Figure 7-10**). This decrease mirrors the downward trend in total HTO emissions from LLNL's Tritium Facility and the closure of Sandia/California's Tritium Research Laboratory. A more than tenfold decrease in total HTO emissions has occurred since



1990, down from 34.9 TBq (943 Ci) to 3.2 TBq (85 Ci). Values for median tritium activity are derived from the six on-site rain sampling locations (Building 343, Building 291, CDB, SALV, VIS, and COW) that historically have given the highest activities. MET was not included because it is upwind of tritium sources.

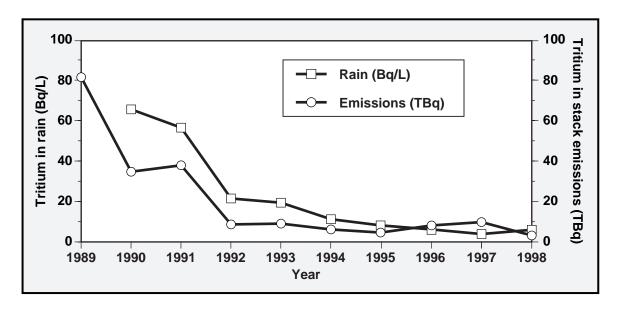


Figure 7-10. Trends of median tritium activity in rain and total stack emissions of HTO from the LLNL Livermore site and Sandia/California, 1990 to 1998. Emissions from 1996–1998 are from LLNL only.

One central location is used to collect rainfall for tritium activity measurements at LLNL's Experimental Test Site, Site 300 (**Figure 7-3**). Rainfall samples are composited (added together) for each month and analyzed when there is sufficient volume. During 1998, rainfall samples were taken at Site 300 in February, March, April, May, November, and December. The measured activities were all either less than the minimum detectable activity or less than the  $2\sigma$  uncertainty. Over the past 26 years, 166 measurements of rainfall samples collected at Site 300 give a maximum tritium activity of only 9.1 Bq/L. The tritium activity measured in rainfall at Site 300 has been indistinguishable from atmospheric background levels over the past 26 years.

# Livermore Site Drainage Retention Basin

## Introduction

The history of the construction and management of the Drainage Retention Basin (DRB) has been recounted in previous Environmental Annual Reports (see Harrach et al.



1995–1997). In 1997, treated ground water began to be discharged routinely to the DRB. In 1998 discharges from Treatment Facility D, Treatment Facility E-East, and portable treatment units became a year round source of water entering the DRB. Wet weather flows into the DRB are still dominated by storm water runoff, but dry weather discharges from the treatment facilities now make up a substantial portion of the total water discharging into the DRB.

The San Francisco Bay RWQCB regulates discharges from the DRB according to the Livermore site CERCLA Record of Decision, as modified by the Explanation of Significant Differences for Metals Discharge Limits at the Lawrence Livermore National Laboratory Livermore Site (Berg 1997c). The Livermore site CERCLA Record of Decision establishes discharge limits for all remedial activities at the Livermore site to meet applicable, relevant, and appropriate requirements derived from the Federal Clean Water Act, the Federal and State Safe Drinking Water Acts, and the Porter-Cologne Water Quality Act.

Changes in the DRB sampling program that were agreed upon in 1997 (Galles 1997) and implemented in 1998 included modifying the parameters and constituents monitored, adding three-level chronic toxicity tests, and establishing a dry season sampling plan. The program consists of monitoring wet and dry weather releases for compliance with discharge limits, monitoring internal DRB water quality to support management actions, characterizing the quality of water before its release, and reporting.

LLNL samples discharges from the DRB (location CDBX) and the corresponding site storm water outfall (location WPDC) during the first release of the rainy season and from a minimum of one additional storm (chosen in conjunction with storm water runoff monitoring). During the dry season, samples are collected from each discrete discharge event. Discharge sampling locations CDBX and WPDC are shown in **Figure 7-2**. Samples are collected at CDBX to determine compliance with discharge limits. Sampling at WPDC is done to identify any change in water quality as DRB discharges travel through the LLNL storm water drainage system and leave the site. Sampling frequencies for CDBX and WPDC and effluent limits for discharges from the DRB, applied at CDBX, are found in Table 7-10 of the Data Supplement.

The routine management constituents, management action levels, and the monitoring frequency are identified in Data Supplement Table 7-11. Sampling to determine whether water quality management objectives are met is conducted at several points within the DRB. Dissolved oxygen (DO) content and temperature are measured at eight locations (**Figure 7-11**). Because of limited variability among sampling locations, all samples, other than those for dissolved oxygen and temperature, are routinely collected from sample location CDBE, located at the middle depth of the DRB.





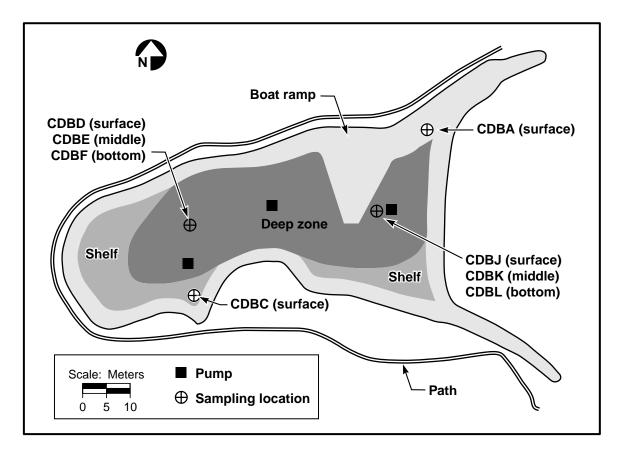


Figure 7-11. Sampling locations within the Drainage Retention Basin, 1998.

For purposes of determining discharge monitoring requirements and frequency, the wet season is defined as October 1 through May 31, the period when rain-related discharges usually occur (Galles 1997). Discharge limits are applied to the wet and dry seasons as defined in the Explanation of Significant Differences for Metals Discharge Limits at the Lawrence Livermore National Laboratory Livermore Site (Berg 1997) (wet season December 1 through March 31, dry season April 1 through November 30).

By agreement with the San Francisco Bay RWQCB, every quarter LLNL submits a report summarizing weekly, monthly, quarterly, semiannual, and annual monitoring of the basin as specified in the amended Drainage Retention Basin Management Plan (The Limnion Corporation 1991). The DRB Management Plan also identifies biological and microbiological surveys that are to be used as the primary means to assess the longrange environmental impact of the DRB. Probable impacts identified in the DRB Management Plan include increased riparian vegetation in Arroyo Las Positas and in the lower portions of the drainage channels tributary to the DRB, and the establishment of sensitive amphibian and bird species within the basin or in Arroyo Las Positas.



LLNL monitors plant and animal species at the DRB, the drainage channels discharging into the DRB, and down stream portions of Arroyo Las Positas. These surveys are conducted semiannually to identify the presence or absence of species. Surveys include amphibians, birds, fishes, and mammals. Plant surveys are also done in the spring and the fall. Microbiological surveys include quarterly sampling for microbiological organisms (zooplankton, algae, and total bacteria counts, blue-green algae, and sulfate producing bacteria). Samples to characterize heterotrophic bacteria sulfate reducing bacteria, and blue green algae populations are collected at location CDBF. Zooplankton and phytoplankton (algae) samples are collected from a measured length of the DRB surface water.

## Methods

Sample collection procedures are discussed in the *Environmental Monitoring Plan* (Tate et al. 1995) and detailed in procedure EMP-W-S. Discharges from the DRB are collected as grab samples from sample locations CDBX and WPDC. Samples collected within the DRB are also collected as grab samples. Field measurements for dissolved oxygen and temperature are made using a dissolved oxygen/temperature meter. Turbidity is measured using a Secchi disk. Samples collected for physical and chemical characterization at locations CDBE, CDBX, and WPDC are analyzed by certified laboratories.

Biological and microbiological methods are discussed in detail in the *Environmental Monitoring Plan* (Tate et al. 1995). Biological surveys are conducted by LLNL's biologist. Animal surveys follow standard survey protocols such as *Raptor Management Techniques Manual* (Pendleton 1987), *Inventory and Monitoring of Wildlife Habitat* (Cooperrider 1986), and *Wildlife Management Techniques Manual* (Schemnitz 1980). Vegetation surveys use protocols identified in the *U.S. Army Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987).

Discrete at-depth grab samples are collected from sample location CDBF for microbiological measurements of heterotrophic bacteria, sulfate producing bacteria, and bluegreen algae. Zooplankton and phytoplankton populations are characterized from samples collected from the DRB surface water across a measured length and concentrated using a 20-µm-mesh plankton net. Zooplankton and phytoplankton are viewed, identified, and counted under a microscope in both fresh and preserved water samples. Total bacterial counts are made following *Standard Methods for the Examination of Water and Wastewater* (Greenberg et al. 1996) using an epifluorescent technique. Heterotrophic bacteria are enumerated using spread-plate methods. Sulfate-reducing bacteria and blue-green algae are characterized by using Hach Biological Activity Reaction Tests.



## Results

Samples collected during 1998 within the DRB at CDBE did not meet the management action levels for dissolved oxygen, temperature, turbidity, nitrate, ammonia, phosphorus, total dissolved solids, chemical oxygen demand, pH, and fecal coliform (Table 7-7). No action was taken to adjust nutrient levels. Operating the pumps to increase the dissolved oxygen level resulted in increased turbidity. No action was taken in response to the temperature changes since the low temperatures were consistent with normal seasonal patterns. All release samples collected at CDBX were below discharge limits.

**Table 7-7.** Summary of Drainage Retention Basin monitoring at sampling location CDBE exceeding management action levels.

Parameter	Management action level	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dissolved oxygen, monthly average (%) (mg/L),	<80% saturation >5 mg/L	62	66 —	54 —	77 —		_	50 4.2	54 4.5	65 —	_	75 —	_
Temperature (°C), monthly average	<15.6 >26.7	10.4	10.4	13.0	_	_	_	-	_	_	_	13.9	9.2
Turbidity (Secchi disk) (m), monthly average	<0.91	0.18	0.15	0.23	0.59	0.73	0.76	0.53	0.28	0.28	0.42	0.44	0.70
Nitrate (as N) (mg/L)	>0.2	0.79	0.5	0.43	_	0.21	_	_	0.4	0.7 <sup>(a)</sup>	1.1	.82	1.9
Ammonia nitrogen (mg/L)	>0.1	_	0.12	0.16	_	0.15	_	0.26	0.2	_	_	_	0.19
Phosphate (as P) (mg/L)	>0.02	0.28	0.67	1.3	0.85	0.34	0.25	0.37	0.38	0.35	0.33	_	0.21
Total dissolved solids (mg/L)	>360	366	_	_	_	_	_	_	394	402	440	_	440
Chemical oxygen demand (mg/L)	>20	32	_	_	27	_	_	_	22	_	27	_	_
pH (pH units)	<6.0 and >9.0	_	_	_	9.01	_	9.35	_	_	_	_	_	_
Fecal coliform (MPN/100 mL)	>400	>1600	900	_	_	_	_	_	_	_	_	_	_

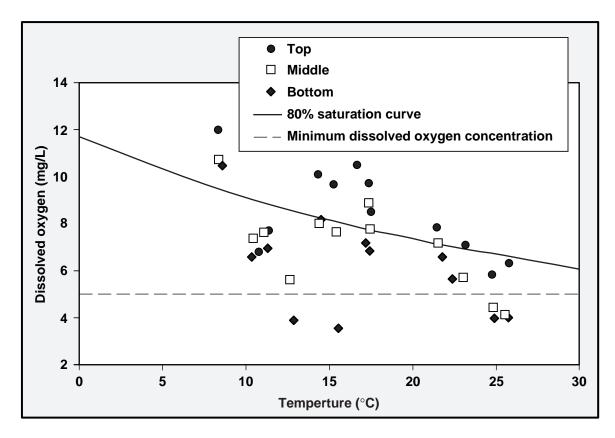
<sup>&</sup>lt;sup>a</sup> Sample preserved so could only detect nitrate plus nitrite as N.



## Dissolved Oxygen

Surface water dissolved oxygen concentration monthly averages were at or above the management action level of at least 80% saturation of oxygen all but three months. Middle and bottom depth samples monthly averages indicated that dissolved oxygen was below 80% saturation in most months. Dissolved oxygen at the bottom and middle levels dropped below the management action level of 5 mg/L during four months in 1998 (Figure 7-12).

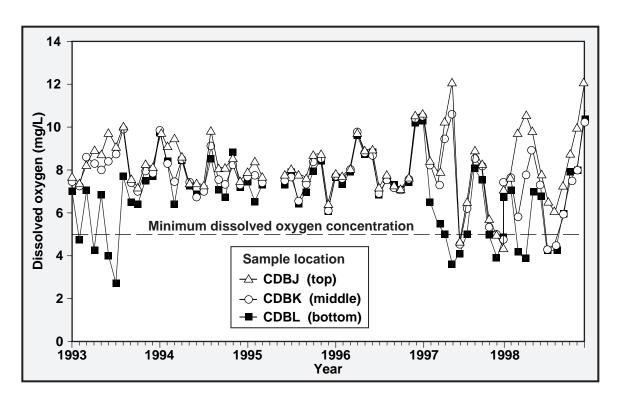
Dissolved oxygen concentrations are controlled manually with aeration pumps, which are started whenever oxygen concentrations at any level of the DRB drop close to or below the critical management action level of 5 mg/L. In 1998, two of these pumps were operated continuously from June through December. During the colder winter months the dissolved oxygen levels were consistently above 5 mg/L and, therefore, the pumps were not operated. Adequate dissolved oxygen concentrations prevent decaying organic matter in bottom sediments from releasing nutrients into the DRB water column.



**Figure 7-12.** Monthly average dissolved oxygen vs. temperature at each depth location in the Drainage Retention Basin from January through December 1998.



Operation of the aeration pumps was probably responsible for the relatively uniform distribution of dissolved oxygen at the surface, middle, and bottom elevations seen throughout the first five years of DRB operation. Halfway through 1997, dissolved oxygen concentrations at the surface, middle, and bottom elevations began uncoupling, indicating for the first time since start-up, that DRB oxygen levels vary from the surface to the bottom. The aerator pumps were no longer able to provide uniform mixing of oxygen at all elevations in the DRB (**Figure 7-13**). The cause of this uncoupling is unknown but may be related to an increase in biomass deposition that increased oxygendemand. Chemical oxygen demand was above management action levels for all four quarters of 1998. Chlorophyll-a was also higher than the historic levels in May, June, July, and December. However, the highest value (40.3  $\mu$ g/L) was still well below the management action level of 10 mg/L. Dissolved oxygen at the surface level was higher during 1998 then in any previous year. This is mostly a result of photosynthesis occurring during daylight hours while algae populations are high. The high oxygen levels correspond to the elevated chlorophyll-a levels.



**Figure 7-13.** Dissolved oxygen concentration variations from the beginning of Drainage Retention Basin operations.

Temperature, the other important parameter in determining how much oxygen is dissolved in water, showed characteristic seasonal trends (**Figure 7-14**). The uniform



distribution of temperature in the top, middle, and bottom elevations reflects that the aerators were providing uniform physical mixing of the water.

## **Turbidity**

Turbidity rose above acceptable management levels during the 1993/1994 wet season and, through 1998, remained mostly above the turbidity management action levels. Wet season turbidity probably results from sediments that pass through the sediment traps discharging into the DRB. Turbidity seen during the warmer summer months is most likely the result of algae growth (Harrach et al. 1996). Turbidity is also caused by the operation of the aerators resuspending sediments and preventing smaller particulates from settling.

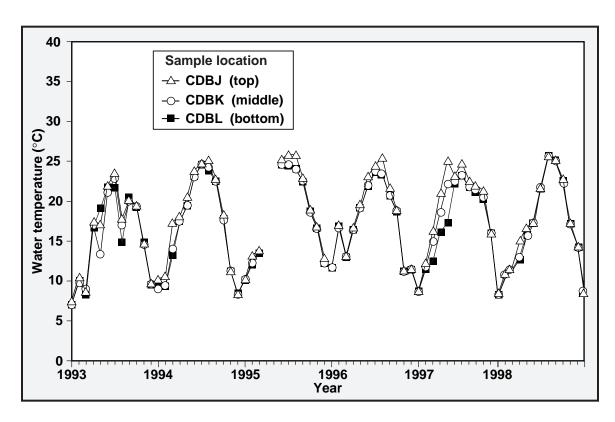


Figure 7-14. Seasonal temperature variation measured at sample top, middle, and bottom levels from the start of operation in 1993. No measurements were made in April and May 1995 because of equipment failure. The high January 1996 value, which was reported in the *Environmental Report* 1997 (Harrach et al. 1998) is almost certainly incorrect and is not in this year's plot.



#### Nutrients

Nutrient levels continued to be high during 1998. Nitrate and total phosphorous concentrations were well above management action levels throughout the year. Nitrate exceeded management action levels for 9 months of the year while phosphorous exceeded management action levels every month. Sources of nitrate and phosphorous include storm water runoff and treated ground water discharges. In addition, ammonia exceeded the management action level during 6 months of the year. Elevated ammonia concentration indicates anaerobic activity. Total dissolved solids began exceeding management action levels for the first time from September 1997 through December 1997. In 1998, total dissolved solids exceeded the management action levels in 5 months. The increased dissolved solids levels correspond to the start of routine treated ground water discharges, which typically have high total dissolved solids. Increasing total dissolved solids often indicates decreasing water quality.

In October 1998, the DRB experienced a mild algae bloom (chlorophyll a levels up to 6 µg/L and the microbiological population dominated by single-cell algae (Aphanizomenon sp. and Peiastrum sp.). Mats of algae growth were visible on the water surface. The algae bloom, high nutrient levels, low oxygen saturation, high temperature, and elevated oxygen demand are believed to have contributed to a bacteria related catfish kill. Approximately 70 dead juvenile catfish were observed between October 14 and October 16. The Department of Fish and Game identified the probable cause of death to be an opportunistic bacteria, Flexibacter columnaris. Annual toxicity tests conducted in October showed no chronic or acute toxicity for fathead minnow and only mild toxicity for the water flea Ceriodaphnia dubia and the algae Selanastrum caprcornutum (two toxicity units each).

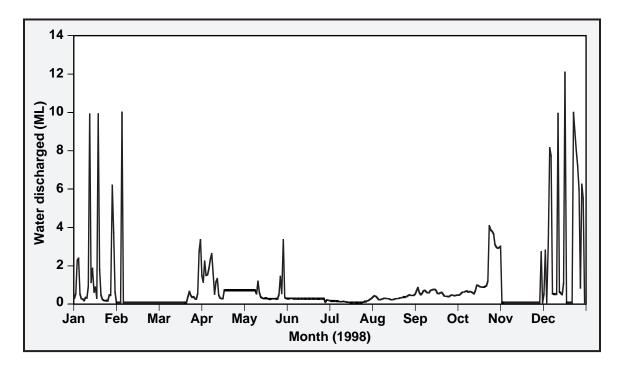
## **Biological Monitoring**

Biological monitoring has not been conducted long enough to identify any trends as a result of the operation of the DRB. However, biological monitoring has shown an expansion in the wetland areas in Arroyo Las Positas as a result of the continuous discharges of water from the DRB and other sources of treated ground water throughout the dry season. The red-legged frog (Rana aurora draytonii), a federally listed threatened species has been identified as present in Arroyo Las Positas, the DRB, and in the southwestern DRB tributary (upstream from sample location CDB).



#### Releases

LLNL began measuring the flow rate discharging from the DRB in 1996 (for 1998 flow, see Figure 7-15). Storm water runoff accounts for the majority of the water entering the DRB in the months from November through April. In May 1998, there was a late storm, which is shown in the peak flow at the end of May. The elevated discharge in late October was the result of a manual release to lower the water level in the DRB to allow adequate capacity for winter storms. 1998 was the first year the DRB received dry season flows from ground water treatment facility discharges in excess of evaporation rates, resulting in continuous discharges from March through early November. A total of 306-ML (81 million gal) of water was discharged from the DRB in 1998. This was approximately twice as much water as was discharged in 1997 and four times as much water as discharged in 1996. The largest discharge occurred on December 17, 1998, when 12 ML of water was released. The majority of the water released from the DRB occurred during the months of January and December.



**Figure 7-15.** Water discharged from the Drainage Retention Basin in 1998.

Mass loading for discharges from the DRB, determined from flow and analytical data, is shown in **Table 7-8**.



Table 7-8. Annual mass loading for detected metals and organic compounds in samples collected from Drainage Retention Basin sampling location CDBX.

	Loadir	ıg (kg)
Parameter	Dissolved	Total
Metals		
Aluminum	nd <sup>(a)</sup>	339
Arsenic	1	1
Barium	38	41
Boron	319	303
Cadmium	nd	3
Chromium`	1	3
Copper	1	2
Iron	19	352
Manganese	nd	13
Nickel	1	4
Vanadium	nd	3
Zinc	7	8
Herbicides		
Bromacil	na <sup>(b)</sup>	504

a nd = Not detected above reporting levels.

Data for maintenance and release monitoring at sampling locations CDBX, WPDC, CDBA, CDBC, CDBD, CDBE, CDBF, CDBJ, CDBK, and CDBL and from the biological and microbiological surveys are presented in Tables 7-12 to 7-18 in the Data Supplement.

# Site 300 Cooling Towers

## Introduction

LLNL samples cooling-tower wastewater discharges as required by the Self-Monitoring Program of WDR 94-131, NPDES Permit No. CA0081396, and reports the results of the compliance sampling to the Central Valley RWQCB quarterly.

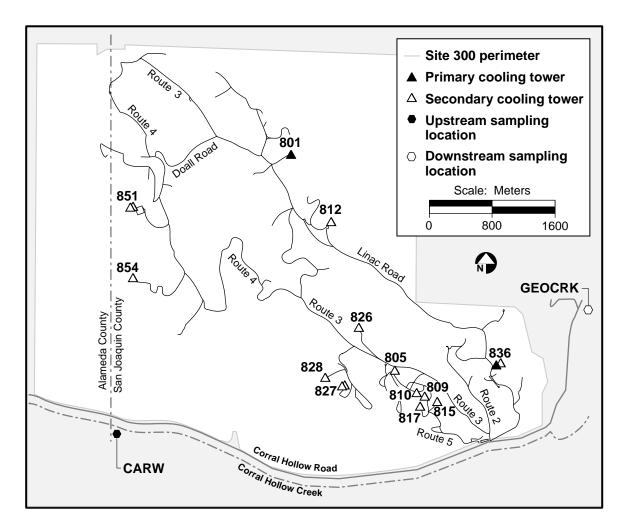
Two primary cooling towers, located at Buildings 801 and 836A, regularly discharge to surface water drainage courses. Fourteen secondary cooling towers routinely discharge to percolation pits under a waiver of waste discharge requirements from the Central

b na = Not analyzed.



Valley RWQCB. The permit establishes separate effluent limits (dissolved solids must not exceed a monthly average of 2000 mg/L or 5000 mg/L daily; pH must not exceed 10) for these 14 towers in the event that discharge to surface water drainage courses is necessary. Two such discharges occurred in 1998 and are discussed later.

As required in the permit, blowdown flow is monitored biweekly from the cooling towers located at Buildings 801 and 836A. TDS and pH are monitored quarterly at both locations. In January 1998, LLNL discovered that the blowdown flow readings for the cooling tower at Building 836A had previously been incorrectly taken from the influent flow meter, which includes make-up water as well as blowdown, rather than from the discharge flow meter. Consequently, LLNL over-reported blowdown flow from the Building 836 cooling tower. All data for 1998 was taken from the correct (discharge) flow meter.



**Figure 7-16.** Site 300 cooling tower locations and receiving water monitoring locations, 1998.



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#### Methods

To determine the effects of the cooling tower blowdown on Corral Hollow Creek, the permit requires quarterly pH monitoring of the creek, both upstream (background) and downstream of the cooling tower discharges. CARW is the upstream sampling location, and GEOCRK is the downstream sampling location. Field pH measurements, taken by LLNL technicians using calibrated meters, are used to monitor Corral Hollow Creek. These technicians also perform the required visual observations, which are recorded on the field tracking forms (FTF) along with the field pH measurements.

Blowdown flow is determined once every two weeks by taking flow meter readings over a time period covering approximately 24 hours. Standard EPA methods are used for sample analysis; method E150.1 for pH, and method E160.1 for TDS.

LLNL maintenance staff take operational TDS and pH measurements biweekly, using calibrated meters. LLNL reports these operational values at the request of the Central Valley RWQCB, but they are not used to determine compliance.

As previously stated, if the blowdown flow from one of the 14 secondary cooling towers is diverted from a percolation pit to a surface water drainage course, the discharge is sampled for pH and TDS. If the discharge continues, that location is monitored in the same manner as the primary cooling towers, i.e. biweekly flow measurements and quarterly pH and TDS monitoring.

## Results

Biweekly and quarterly monitoring results are detailed in the quarterly self monitoring report to the Central Valley RWQCB. Summary data from primary cooling tower compliance monitoring and operational monitoring are found in **Tables 7-9** and **7-10**, respectively.

All pH samples collected from the cooling tower discharges were below the permitted maximum of 10. All TDS concentrations were below both the daily maximum (2400 mg/L) and monthly average (2000 mg/L) limits. These monitoring results demonstrate that cooling tower discharges were consistently in compliance with permitted limits (see **Tables 7-9** and **7-10**). As mentioned earlier, operational values are reported at the request of the Central Valley RWQCB, but they are not used to determine compliance.



**Table 7-9.** Summary data from compliance monitoring of Site 300 primary cooling towers, 1998.

Test	Tower no.	Permitted maximum	Minimum	Maximum	Median	Interquartile range	Number of samples
Total dissolved solids (TDS) (mg/L)	801	2,400	970	1,500	1,250	(a)	4
	836A	2,400	1,100	1,400	1,250	(a)	4
Flow (L/day)	801	16,276	0	14,211	3,923	5,713	26
	836A	8,138	0	5,495	1,438	1,735	26
pH (pH units)	801	10	8.8	9.1	9	(a)	4
	836A	10	8.8	9.1	8.9	(a)	4

a Not enough data points to determine.

**Table 7-10.** Summary data from operational monitoring of Site 300 primary cooling towers, 1998.

Test	Tower no.	Permitted maximum	Minimum	Maximum	Median	Interquartile range	Number of samples
Total dissolved solids (TDS) (mg/L)	801	2,400	1,100	1,500	1,400	150	26
	836A	2,400	1,000	1,400	1,200	150	26
pH (pH units)	801	10	8.7	9.1	9.0	0.1	26
	836A	10	8.8	9.1	9.10	0.1	26

During 1998, flow occurred in Corral Hollow Creek during the first and second quarters, and at the downstream location only during the fourth quarter. There was no flow in Corral Hollow Creek during the third quarter.

Inadvertently, no Corral Hollow Creek samples were collected for the cooling tower monitoring program during the first quarter. However, data were obtained from storm water monitoring samples collected during this monitoring period from the same upstream (CARW) and downstream (GEOCRK) locations. Storm water sampling was at pH 8.3 at both sampling locations, verifying that the pH did not exceed the 8.5 permit limit, and that the ambient pH had not changed by more than 0.5 unit.

For the second quarter, pH monitoring was done on two separate dates. The May 13, 1998, results were 8.5 pH units at both the upstream and downstream locations. On June 24, 1998, the upstream pH was 8.29, and the downstream pH was 8.04 units. Both results are within the permitted range of 6.5 to 8.5 and indicate that cooling tower discharge did not alter the ambient pH by more than 0.5 pH units.



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During the fourth quarter, flow was observed in Corral Hollow Creek at the down-stream location only. The quarterly pH sample collected on November 10, 1998, resulted in a pH of 8.52. Though this is above the 8.5 permit limit, biweekly flow monitoring data show that neither cooling tower discharged that day. Therefore, the cooling towers were not the cause of the slightly elevated pH.

Visual observations of Corral Hollow Creek were performed each quarter as required in the permit. No visible oil, grease, scum, foam, or floating suspended material was noted in the creek during 1998.

Two discharges occurred from secondary cooling towers in 1998; one from the Building 812 cooling tower percolation pit, and one from the Building 827 cooling tower percolation pit. On July 21, 1998, the Building 812 cooling tower float valve stuck in the open position, with the result that the capacity of the percolation pit was exceeded and the pit overflowed to ground. LLNL maintenance staff diverted the flow from the pit to the ground until the pit was drained. The valve was repaired the same day, and flow returned to the percolation pit on July 23, 1998. As required by the permit, monitoring samples were collected on July 21, 1998. Analytical results (990 mg/L TDS; 8.88 pH units) were below the permit limits.

The Building 827 percolation pit overflowed on August 4, 1998, when water discharged during cooling tower maintenance exceeded the capacity of the pit. Approximately 75 to 100 gallons were discharged to the ground. No samples were taken because the discharge was small and had ended before a sampling team could be deployed.

## Other Waters

## Introduction

Additional surface water monitoring is driven by DOE Order 5400.1, General Environmental Protection Program, and DOE Order 5400.5, Radiation Protection of the Public and the Environment. Surface and drinking water near the LLNL Livermore site and in the Livermore Valley are sampled at locations shown in **Figure 7-17**. Sampling locations DEL, ZON7, DUCK, ALAG, SHAD, and CAL are surface water bodies; of these DEL, ZON7, and CAL are drinking water sources. BELL, GAS, PALM, ORCH, and TAP are drinking water outlets. Location POOL is the on-site swimming pool. Data from drinking water sources and drinking water outlets are used to calculate drinking water statistics (see **Table 7-11**) and doses.



## Methods

Samples are analyzed for gross alpha, gross beta, and tritium, according to procedures set out in Appendix A of the *Environmental Monitoring Plan* (Tate et al. 1995). LLNL sampled these locations semiannually for gross alpha, gross beta, and tritium. The on-site swimming pool (POOL) was sampled semiannually for gross alpha and gross beta, and quarterly for tritium.

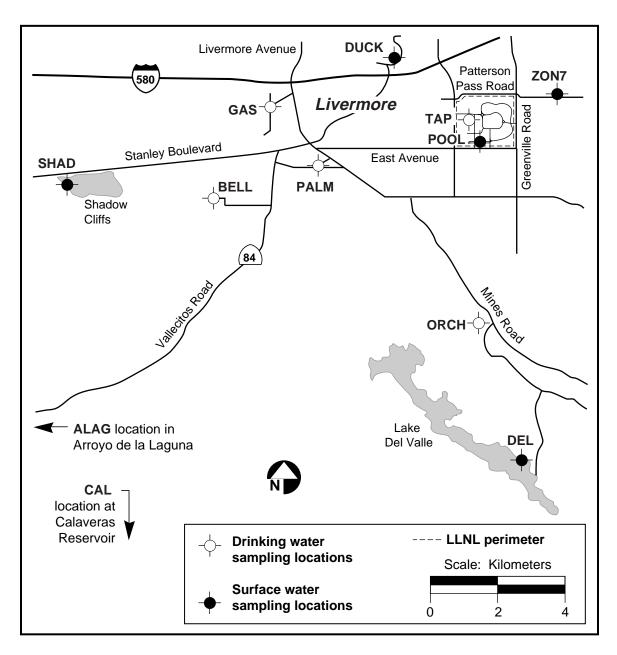


Figure 7-17. Surface and drinking water sampling locations, Livermore Valley, 1998.



## Results

Median activity for tritium was less than 0.2% of the drinking water Maximum Contaminant Level (MCL); the maximum tritium activity was 1% of the MCL. Median activities for gross alpha and gross beta radiation in surface water samples were approximately 5% of the MCL. However, maximum activities detected for gross alpha and gross beta, respectively, were 0.19 Bq/L (5.1 pCi/L) and 0.31 Bq/L (8.3 pCi/L) or 34% and 17% of their respective MCLs (see **Table 7-11**). Detailed data are in Table 7-19 of the Data Supplement. Historically, gross alpha and gross beta radiation have fluctuated about the laboratory reporting limits. At these very low levels, the error measurements are nearly equal to the measured values so that no trends are apparent in the data.

**Table 7-11.** Radioactivity (in Bg/L) in surface and drinking water in the Livermore Valley, 1998.

	Tritium	Gross alpha	Gross beta
All locations			
Median	<1.22	0.02	0.10
Minimum	<0.91	-0.01	-0.05
Maximum	7.81	0.19	0.31
Interquartile range	0.33	0.05	0.11
Drinking water locations			
Median	<1.20	0.02	0.08
Minimum	<0.91	-0.01	-0.05
Maximum	2.07	0.12	0.27
Interquartile range	0.12	0.04	0.11

# **Environmental Impacts**

## Storm Water

The potential off-site impact of tritium was estimated by determining the effective dose equivalent (EDE). Appendix A presents the method to calculate dose. Maximum tritium activity in storm water (runoff) was 31.4 Bq/L, about 4% of the MCL (see **Table 7-2**). The EDE to an adult who ingested two liters of water per day at the maximum storm water tritium concentration for one year would be less than 0.0004 mSv (0.04 mrem), or 0.04% of the 1 mSv DOE standard allowable dose for ingestion. Maximum gross alpha and gross beta activities in storm water were 0.38 and 0.32 Bq/L, or 68% and 17% of their respective MCLs (see Table 7-2). Past studies, however, have indicated that the majority of the gross alpha and beta activities observed in runoff are due to naturally occurring radioisotopes carried by sediments in the runoff.



Concentrations of some metals in storm water seem to be increasing. Preliminary results indicate that these levels are related to suspended solids in the storm water. Further investigation into the source of these metals is planned. Samples collected during the 1998/1999 wet season for both dissolved and total metals will be evaluated to determine how much of the increase can be attributed to LLNL activities, to off-site sources, and to naturally occurring sediments. Although some 1997 storm water results were above criteria, there is no evidence that indicates any impact to off-site biota. The acute and chronic fish toxicity tests conducted during 1997 for the 1997/1998 wet season further support the conclusion that LLNL storm water has no adverse effect on off-site biota.

## Rainfall

The environmental impact of tritium measured in rainfall samples from the Livermore site was negligible. The median tritium activity measured in rainfall at the Livermore site has slightly increased from 3.85 Bq/L (104 pCi/L) in 1997 to 5.59 Bq/L (151 pCi/L) in 1998. However, median tritium activity measured in rainfall on site at LLNL has decreased more than tenfold since 1990: down from 65.9 Bq/L (1780 pCi/L) to 5.59 Bq/L (151 pCi/L).

The measured tritium activities of rainfall samples taken at Site 300 were all either less than the minimum detectable activity or less than the 2  $\sigma$  uncertainty. Over the past 26 years, 166 measurements of rainfall samples collected at Site 300 give a maximum tritium activity of only 9.1 Bq/L. The tritium activity measured in rainfall at Site 300 has been indistinguishable from atmospheric background levels over the past 26 years.

## Drainage Retention Basin

There is no evidence of adverse environmental impact resulting from releases from the Drainage Retention Basin. Although internal measurements indicated that concentrations were above the management action levels for several constituents, no water was discharged with constituents above allowed limits. Though mild toxicity was observed in the DRB and in water discharged from the DRB, there is no evidence that the discharge had an effect on downstream receiving water. Because of the continuous discharge that occurred last year from the DRB and ground water treatment facilities and the wetter than normal rainfall years that occurred during 1997 and 1998, there has been an increase in wetland areas on site both up and down stream of the DRB. The



# **Surface Water**

federally listed threatened red-legged frog has colonized these wetland areas. The operation of the DRB has contributed to this habitat formation.

# **Cooling Towers**

Both primary cooling towers that discharge to surface were within their permitted limits for flow, pH, and TDS. Thus, data indicate no negative impact to surface waters from these cooling towers. The secondary cooling tower percolation pit overflow at Building 812 was also within permitted limits, which indicates no negative impact to surface waters from this one-time event.

The discharge from the 827 cooling tower percolation pit overflow did not reach the receiving water; due to its small size it immediately percolated to ground. Therefore, though confirmation data are not available, there was no negative impact to surface water from this one-time event.

Since blowdown flow from the cooling towers does not reach Corral Hollow Creek, it is unlikely to have a negative impact to the receiving water. Run-off from livestock areas, or natural pH variations may have a more significant impact than cooling tower blowdown.

## Other Waters

The potential impact of tritium on drinking water supplies was estimated by determining the effective dose equivalent (EDE). Appendix A presents the method to calculate dose. Maximum tritium activity in drinking waters (see **Table 7-11**) was 2.07 Bq/L (55.9 pCi/L). The EDE to an adult who ingested two liters of water per day at this maximum concentration for one year would be 0.00003 mSv (0.003 mrem), or 0.06% of the DOE standard allowable dose of 0.04 mSv for drinking water systems. Gross alpha and gross beta activities were well below their MCLs. The sample data indicate that the impact of LLNL Livermore site operations on surface and drinking waters is negligible.